PATENT SPECIFICATION

635,619

Date of Application and filing Complete Specification: Feb. 21, 1947.

No. 5209/47.

Application made in United States of America on Feb. 26, 1946.

Complete Specification Published: April 12, 1950.

Index at acceptance:—Class 40(viii), U18(a2: b3).

COMPLETE SPECIFICATION

Improvement in Coupling Arrangements for Electrical Resonators

We, RADIO CORPORATION OF AMERICA, a corporation organised under the laws of the State of Delaware, United States of America, of 30 Rockefeller Plaza, New York, United States of America, assignees of ROBERT LAMB SPROULL, of Fisher Place, Princeton, Mercer County, New Jersey, United States of America, a citizen of the United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :—

This invention relates to resonator arrangements for use on very high frequencies and has for its main object to provide improved variable-coupling wide-frequency-band tunable microwave resonators of the type utilizing a movable piston-like member (hereinafter termed simply a piston) for adjustment purposes.

It is customary to utilize adjustably tuned microwave resonators as frequency controlling or filter elements in microwave generators, mixers and transmission systems and the like. The resonant frequency of such microwave resonators may be varied by longitudinal adjustment of a conductive piston enclosed within the resonator shell. Well known methods of coupling into or out of such adjustable resonators include the use of microwave probe elements, coupling loops and adjustable aperture devices, depending upon the characteristics of the circuit to which the resonator is coupled. It is frequently advantageous to be able to vary the degree of coupling between an external circuit and the microwave resonator as the resonator is tuned through its useful frequency band. In particular, in reflex oscillators of the type including an electron reflecting electrode, it is often desirable that the coupling coefficient between the oscillator and the load circuit shall remain substantially constant or decrease as the oscillator frequency is increased. A conventional coupling loop, probe or aperture device coupled into the oscillator cavity normally will provide an increased coupling coefficient as the frequency is increased, thereby providing non-linear loading of the oscillator over its useful frequency range.

In our patent specification No. 5727/47 we have described microwave hollow resonator arrangements wherein the frequency of the resonators is varied by longitudinal adjustment of a piston operative therein, and wherein the effective length of a coupling probe, or the angular displacement of a coupling loop, or the effective opening of an aperture device is simultaneously adjusted by movement of the tuning piston. The specification in question describes means for tuning a microwave resonator and simultaneously adjusting the coupling thereto from an external coaxial line or waveguide.

The present invention provides a variable-coupling wide-frequency-band microwave coaxial line resonator including a movable piston having an aperture therein disposed within and between the resonator conductors. A coupling loop of uniform cross-section terminates a coaxial line connected to an external device. The loop extends through the resonator and through the aperture in the tuning piston. Longitudinal adjustment of the tuning piston thus controls the resonator frequency and the coupling coefficient of the loop in opposite sense. Since there is no contact between the loop and the movable piston, the commonly erratic characteristics of movable contacts at microwave frequencies is eliminated so far as coupling is concerned. A modification of the invention utilizes a coupling loop having a tapered form whereby the coupling coefficient may be caused to change in accordance with a predetermined non-linear function of the resonant frequency of the resonator.

The invention is illustrated in and further described with reference to the accompanying drawings in which Figure 1 is a cross-sectional elevational view of one

embodiment of the invention ; Figure 2 is a plan, partially cross-sectional view along the section line II—II of the device shown in Figure 1 ; and Figure 3 is a cross-sectional, elevational view of a second embodiment of the invention. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figures 1 and 2 the microwave resonator arrangement therein shown includes inner and outer coaxially disposed conductors 1, 3, wherein the outer conductor includes a closed end portion 5. The resonator is tuned by means of a longitudinally adjustable piston 7 having an aperture 9 disposed therein in the region between the inner and outer coaxial line conductors. The longitudinal adjustment of the piston 7 may be effected by means of actuator bars 10 connected to any desired type of actuating mechanism not shown. The piston 7 includes a pair of approximately cylindrical slotted spring contact elements 11, 13, which contact the outer and inner resonator conductors, respectively, to insure uniform electrical contact with the piston.

A second coaxial line having an outer conductor 15 and an inner conductor 17 is terminated within the tunable resonator by means of a "hairpin" coupling loop 19. The coupling loop 19 extends through the part of the structure between the end face 5 and the tuning piston 7 and also extends through the aperture 9 in the tuning piston 7.

Thus, as the resonant frequency of the resonator 1 is changed by advancement of the piston face toward the end resonator wall 5, the lengths of the coupling loop exposed to the resonator cavity are changed thereby tending to change the coupling between the resonator and the external coaxial line 15, 17. The coupling from the masked portion of the loop through the aperture 9 to the resonator cavity is practically negligible. Depending upon the circuit parameters, the coupling coefficient to an external circuit, not shown, may be maintained substantially constant throughout the useful frequency range of the resonator, or the coupling coefficient may be reduced as the frequency is increased. Since the loop does not make contact with the movable piston and is fixed with respect to the resonator walls, erratic operation due to varying contact resistances is minimized.

The device illustrated in Figure 3 is similar to that of Figures 1 and 2, except that the coupling loop 19^1 is of predetermined non-linear form so that longitudinal adjustment of the tuning piston 7 varies the coupling coefficient of the coupling loop 19^1 according to a predetermined desired non-linear function of the operating frequency of the resonator. The shape of the coupling loop 19^1 may be varied in accordance with the desired coupling coefficient characteristic to provide either constant coupling or variable coupling in opposite sense to the variation of the resonant frequency of the resonator as the piston position is adjusted.

Apparatus in accordance with this invention may be employed as either output or input coupling elements for associated circuits and for simultaneous or separate control of a plurality of such coupling elements may be provided for a single resonator or for a plurality of resonators. By proper proportioning of the adjustable resonator and the associated coupling loop or loops, the coupling coefficient to external circuits may be maintained substantially constant or varied in opposite sense to the adjustment of the resonator frequency.

Thus, the invention provides wide-frequency-band coaxial microwave resonators having tuning and frequency variation by adjustment of a tuning piston and wherein piston adjustment provides desired control of the coupling coefficient between said resonator and an external circuit.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is :—

1. A wide-band microwave resonator arrangement including a coaxial line section, a movable piston for varying the tuning thereof, and a coupling element, wherein the piston is provided with an aperture therein through which the coupling element extends into said resonator, the arrangement being such that movement of the piston to vary the resonant frequency of the resonator simultaneously varies the effective length of the element exposed to the field within the resonator so as to vary coupling coefficient of said element to said resonator in an opposite sense to the variation in frequency.

2. A wide band microwave resonator arrangement including a coaxial line section, a movable piston for varying the tuning thereof, and a coupling element, wherein the piston is provided with an aperture therein through which the coupling element extends into said resonator, the arrangement being such that movement of the piston to vary the resonant frequency of the resonator simultaneously varies the effective length of the element exposed to the field within the resonator so as to produce substantially no variation in the coupling coefficient of the coupling elmente to the resonator.

3. A resonator as claimed in either of the preceding claims wherein the coupling element is a coupling loop.

4. A resonator as claimed in claim 3, wherein the width of the coupling loop is constant throughout the length of it which extends through said aperture into said resonator.

5. A resonator as claimed in claim 3, wherein the width of the coupling loop varies in a predetermined manner throughout the length of it which extends through said aperture into said resonator, for the purpose stated.

6. Adjustable microwave resonator arrangements substantially as herein described and illustrated in the accompanying drawings.

Dated this 21st day of February, 1947.
CARPMAELS & RANSFORD,
Agents for Applicants,
24, Southampton Buildings,
Chancery Lane, London, W.C.2.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1950.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies, price 2s. 0d. each (inland) 2s. 1d. (abroad) may be obtained.

[This Drawing is a reproduction of the Original on a reduced scale.]

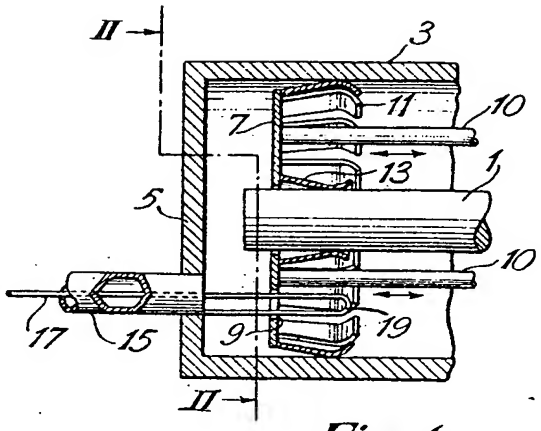

Fig. 1.

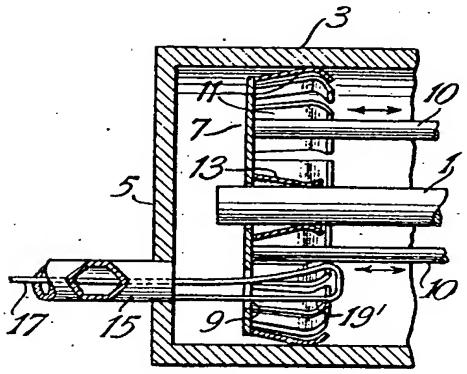

Fig. 3.

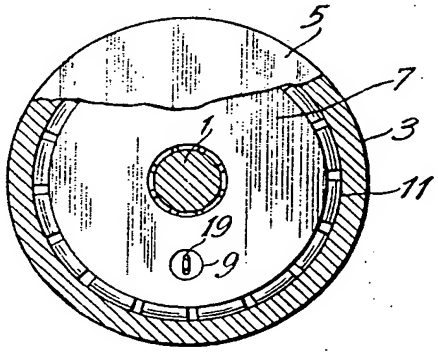

Fig. 2.

H.M.S.O. (Ty. P.)